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PRELIMINARY ASSESSMENT OF DATA FROM THE MADISON COUNTY LEAD STUDY AND IMPLICATIONS FOR REMEDIATION OF LEAD-CONTAMINATED SOIL

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1. INTRODUCTION

The data on blood lead, environmental lead, and family interviews for 490 children in Madison County, Illinois, were provided to us by the Institute for Evaluating Health Risks (IEHR) through the U.S. Department of Justice. The study was carried out in 1991 by U.S. EPA, Illinois EPA, the Illinois Dept. of Public Health (IDPH) and the Agency for Toxic Substances and Disease Registry (ATSDR). We requested access to the data from IDPH, which was provided by their contractor, IEHR. Evaluating Health Risks (IEHR). The data were sent to us on diskette in ASCII format. We converted these data into a SYSTAT (Wilkinson 1992) data file, from which all subsequent analyses reported here were performed. Additional analyses will require creation of SAS data sets. Analyses of the data were reported by IDPH (February 1994) and in a more compact form by ATSDR (May 1994). U.S. EPA provided a critical review of these analyses (Marcus et al., May 1994).

The purposes for our reanalyses of the data are:

1. To assess the results described in (IDPH 1994) for use in evaluating childhood lead exposure in Madison County;

2. To provide site-specific information about relevant parameters in the EPA Integrated Exposure, Uptake, and Biokinetic Model for Lead (IEUBK Model);

3. To evaluate the proposed soil remediation level of 500 ppm using this recent information.

This is only a very preliminary report of results. A more detailed report will be prepared, describing the methods used in the analyses, a complete set of results, and the basis for our conclusions. This report is divided into the following sections. Section 2 reports the results of the preliminary analyses. Complete technical details will follow in a subsequent report. Section 3 presents the basis for a soil lead cleanup level. Section 3.1 deescribes the empirical basis for the findings, which combines personal observation of the site, results of data analyses, and professional judgements about the site. Section 3.2 describes the soil lead results when input values for the IEUBK Model from Section 3.1 are used, and describes the reevaluation of the soil lead cleanup level for the site.

2. SUMMARY AND CONCLUSIONS FROM DATA ANALYSES

A large number of graphs using these data are attached. The following results are based on these figures. Note that with few exceptions, the logarithms of the environmental lead concentrations and blood lead concentrations were used since the distribution of each variable is skewed to the right. All are "natural" base e logarithms, not common base 10 logarithms. The error bars on the graphs show the standard error of the (geometric) mean. The exact distance of the household from the NL site is not in the data set, only location within (approximate) 1/8 mile rings around the smelter. No information is provided about the quadrant or direction from the smelter site, and no information is provided about the city or township where each child lives.

We reanalyzed data on 490 pre-school age children in 351 households in Madison County, Illinois. These data contain no information on location within the study area, apart from approximate distance of the child's household from the NL/Taracorp site ("NL site"), and in particular do not identify the child's community of residence, so the results cannot be ascribed to any locale such as Granite City, Madison, or Venice. Our analyses of these data showed that:

1. Sixteen percent of the children had blood concentrations of 10 ug/dl or greater in the Madison County study area as a whole, but the percentage of lead-burdened children increased with decreasing distance from the NL smelter site. The increase was from 7 percent of children living at a distance greater than 0.75 miles from the NL site to about 26 percent of children in the study who lived in the area closest to the site. The areas closest to the site would be considered as appropriate for remediation, based on remedial investigations, by current EPA criteria. (Figure 1)

2. The percentage of children in the study with blood lead concentrations of 15 ug/dl or greater increased from about 2 percent of children living at a distance greater than 0.75 miles from the NL site to about 9 percent of children within 0.4 miles of the site. None of the children living at a distance of a mile or more from the NL site had a blood lead of 20 ug/dl or greater, whereas about 5 percent of the pre-school children who lived within half a mile from the NL site had a blood lead of at least 20 ug/dl. A blood lead concentration of 20 ug/dl is well above EPA's level of concern of 10 ug/dl and is associated with a substantially increased risk of permanent and irreversible neurobehavioral damage. Current CDC guidelines recommend individual environmental or medical intervention with children whose blood lead concentrations are at least 20 ug/dl. (Figures 2 and 3).

3. Blood lead concentration, soil lead concentration, and house dust lead concentration show very similar patterns of decreasing concentration with increasing distance from the NL site, on average. Loadings of deteriorating lead paint inside and outside the house show little or no relationship to distance from the NL site. This suggests that deteriorating lead-based paint is not the most important environmental

factor in childhood blood lead in Madison County, and is much less important than soil lead and dust lead. (Figures 4, 4a, 5, 6, 7, 8).

4. Tap water lead concentrations are highest, on average, in the area closest to the NL smelter, but show little relation to distance from the site farther away. This suggests that tap water lead may be a contributing factor, but is not the primary environmental factor in childhood blood lead in the Madison County study. (Figure 9).

5. Total dust loading shows almost no relationship to distance from the NL site, on average, so that increased dustiness of homes cannot explain the higher household dust lead loadings found near the NL site; it is the higher concentration of lead in household dust that accounts for higher dust lead loadings near the NL site. Further studies are needed to determine whether this is an artifact of the method of house dust sampling, or whether this is a generalizable conclusion. (Figures 10, 11).

6. Lead in household dust is the primary exposure pathway for young children. Lead in soil and lead in deteriorating lead-based paint are primary sources for lead in house dust, with substantial variability from one household to another.

7. Many socio-demographic factors are related to individual childhood blood lead concentrations, and also show a systematic relationship to distance from the NL site. These include increasing parental education, increasing income, and decreasing numbers of pre-school children per household with increasing distance from the smelter. Households in the study with the most children and the fewest resources to cope with lead poisoning are located closest to the NL site. (Figures 12, 13, 14, 15).

8. Individual child-specific behaviors may affect blood lead concentration, with substantial differences among children. These include hours of outdoor play, frequency of mouthing non-food objects, and hours of indoor play on the floor. There are some systematic relationships, such as a highly significant tendency for children in the study who live closer to the site to have more hours of outdoor play, on average, than children who live farther away (Figures 16, 17) and 17a.

9. In view of correlations that were found between distance from the NL site, blood lead, environmental lead, household socio-demographic characteristics, and typical child behavior, there are some concerns that the sample of children may not be representative of the community. This study used volunteer subjects. The lowest response rate was in the zone farthest from the NL site, 39 percent. Response rates were similar in the other three zones closer to the NL site, respectively 51 percent in the closest zone, 60 percent in the next closest, and 53 percent in the next closest. One must assume that there were no systematic biases in recruitment related to important factors that affect child blood lead, such as socio-economic status or behavior.

10. Percentage of explained variability in the logarithm of blood lead is not a

useful criterion in model assessment, since it depends on the range and the distribution of predictor variables within the data set. In comparison with all other studies of child blood lead data that EPA has performed, including urban and rural sites, active and inactive lead smelter or lead mining sites, the child blood lead data from the Madison County study has a <u>higher</u> percentage of explained variation (40 percent) than most other studies, and environmental lead explains a comparable percentage of variance (18 percent in our analyses) to other inactive smelter sites. Both the magnitude and strength of the relationships between blood lead and environmental lead are comparable to those we have seen at other sites. The linear regression relationships for blood lead vs. lead in soil, dust, and drinking water are statistically significant in all appropriate model specifications.

3. CALCULATION OF SOIL LEAD CLEANUP CONCENTRATIONS.

3.1. SUMMARY AND CONCLUSIONS: SITE-SPECIFIC PROPERTIES FOR RISK ASSESSMENT

1. The NL/Taracorp site appears to have properties that are characteristic of other recently inactive lead smelter sites. The areas closest to the site have soil and dust lead concentrations that are appropriate to airborne particulates from smelter emissions. These particles are generally easily transported from exterior soil into household dust, and are likely to be small, soluble, and highly bioavailable.

2. These analyses, plus observation of Granite City neighborhoods closest to the NL site, show that:

(i) there are many young children in the community,

(ii) children often play outdoors for much of the day,

(iii) residential yards often contain large bare areas without grass cover,

(iv) adjacent yards are often not fenced and are readily accessible to young children,

(v) the residential areas are surrounded by industrial areas and by transportation routes that contribute to the total environmental impact on these children.

3.2. SOIL LEAD CLEANUP LEVELS USING THE IEUBK MODEL

1. Site-specific parameters were based on our judgement and analyses that the NL site had many points of similarity to the calibration site, Midvale, and that it is appropriate to assume no mitigating factors that may reduce childhood exposure to dust and soil.

2. The default parameters with an assumed soil-to-dust coefficient of 70 percent provided a very good fit to the blood lead data, in terms of geometric mean blood lead, percentiles of the blood lead distribution, and reasonable correlation between observed

and predicted blood lead. The over-all goodness of fit was comparable or better to that for the calibration community, the lead smelter community of Midvale, Utah. (Figures 18, 19, 20).

3. Sensitivity analyses were based on a range of values for the contribution of lead-contaminated soil to household dust. The default assumption, that the concentration of soil-derived lead in house dust is 0.70 of the soil lead concentration, was judged to be appropriate, and also provided a very good fit to the child blood lead data from the Madison County study. Alternative values in the sensitivity analyses were based on statistical analyses from study data: 0.29 (distances up to 1/4 mile), 0.46 (all data), and 0.55 (distances to 3/8 mile). The curvilinearity in the blood lead vs. environmental lead relationship was characterized by a passive-to-total gut lead absorption fraction of 0.20, as found from in-vitro studies. The higher dust/soil coefficients of 0.70 and 0.55 are more appropriate for risk assessment, more realistic for properties of the site, and provide a good fit to the data.

4. Remediation goals for soil abatement were calculated from the IEUBK Model so as to generate not more than 5 percent of children of ages 6 to 84 months with blood lead 10 ug/dl or greater. The calculated soil lead concentrations depended on the assumptions one made about soil to dust transport, but otherwise assumed only default parameters. The soil remediation levels ranged from 340 ppm (soil-to-dust coefficient = 0.70) to 480 ppm (soil-to-dust coefficient of 0.29). This suggests a range of soil lead cleanup values of 400 to 500 ppm. The results are shown in Table 1.

REFERENCES

1. Illinois Department of Public Health, 1994. Madison County Lead Exposure Study, Granite City, Illinois. Draft for public comment. Springfield, Illinois, Feb. 1994.

2. Marcus A.H., Hogan K., White P., Van Leeuwen P. 1994. Comments on Madison County Lead Exposure Study, Granite City, Illinois. In-house memo, U.S. Environmental Protection Agency, May 1994; corrected draft, Sept. 18, 1994. Research Triangle Park, NC.

3. Agency for Toxic Substances and Disease Registry, 1994. Comments on Multisite Lead and Cadmium Exposure study with Biological Markers Incorporated. Review draft. Atlanta, Georgia.

4. Wilkinson, L. 1992. SYSTAT: The System for Statistics. Systat Inc., Evanston IL.

TABLE 1
SENSITIVITY ANALYSES FOR SOIL LEAD CLEANUP LEVELS

SOIL CONTRIBUTION TO HOUSE DUST	SOIL LEAD CLEAN-UP CONCENTRATION (ppm)
0.70 (default)	340
0.55	370
0.46	420
0.29	480

PERCENT WITH BLOOD LEAD 10+ VS. DISTANCE FROM NL S

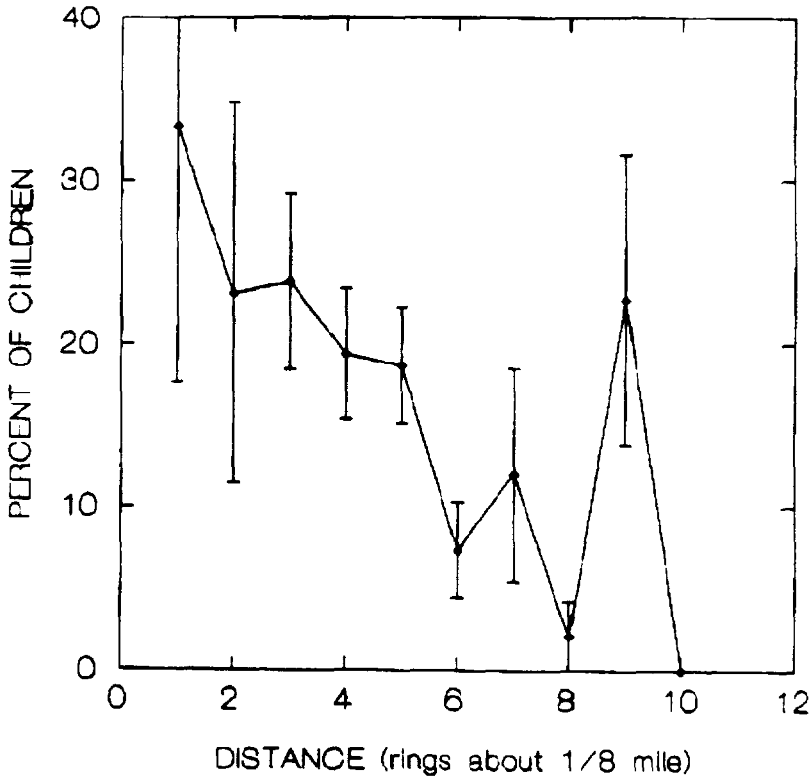

FIGURE 1

PERCENT WITH BLOOD LEAD 15+ VS. DISTANCE FROM NL S

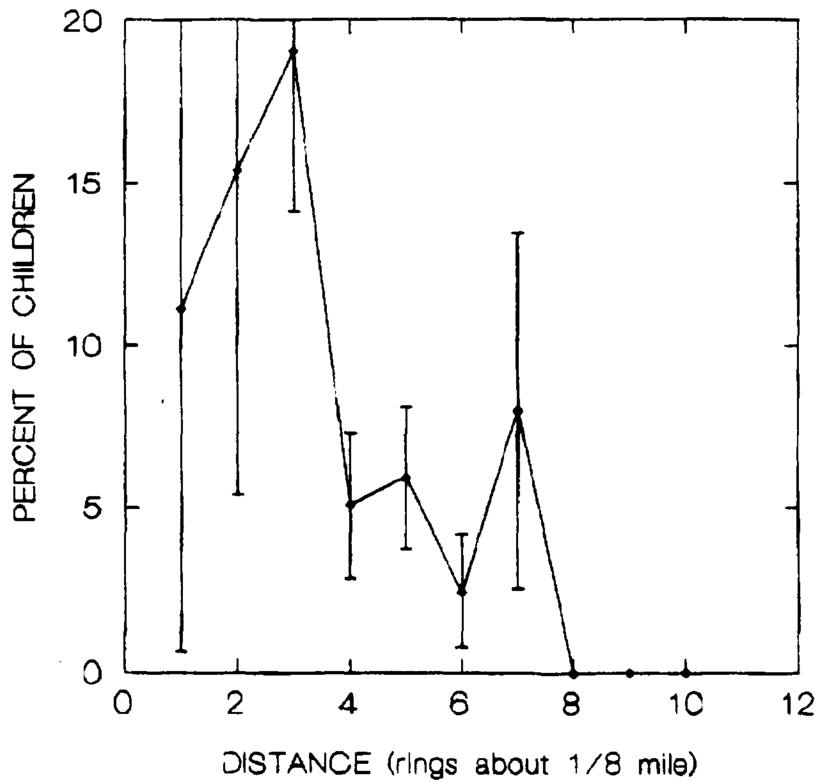

FIGURE 2

PERCENT WITH BLOOD LEAD 20+ VS. DISTANCE FROM NL S

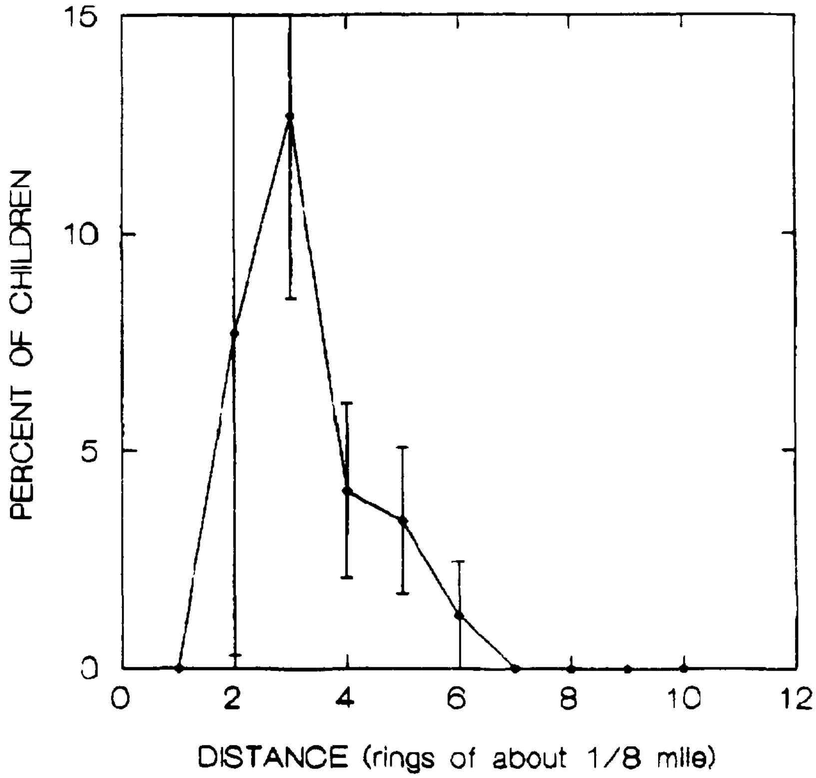

FIGURE 3

MEAN BLOOD LEAD VS. DISTANCE FROM NL SITE

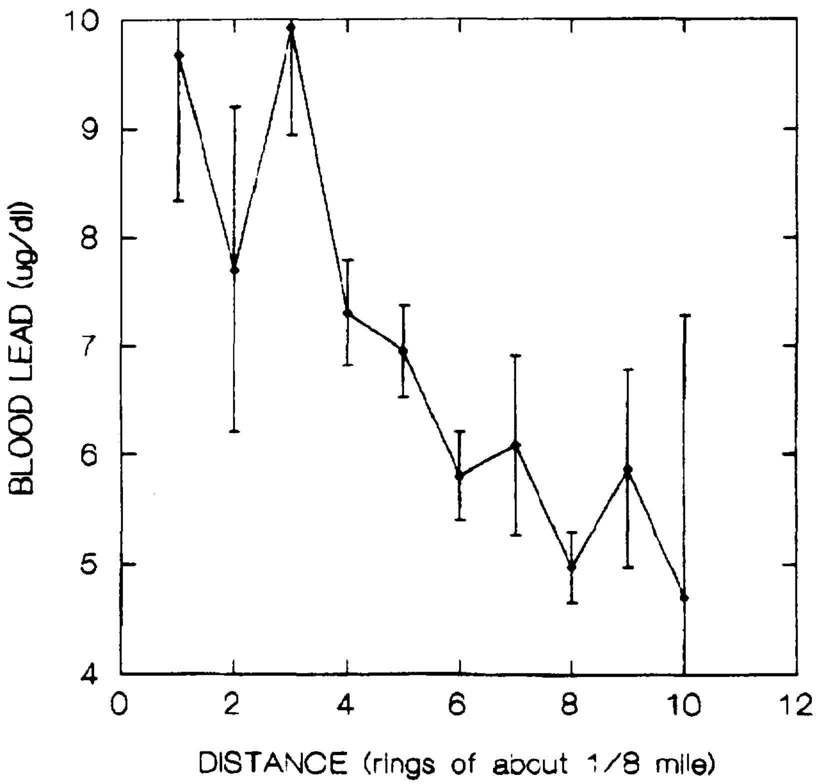

Figure 4

MEAN LOG BLOOD LEAD VS. DISTANCE FROM NL SITE

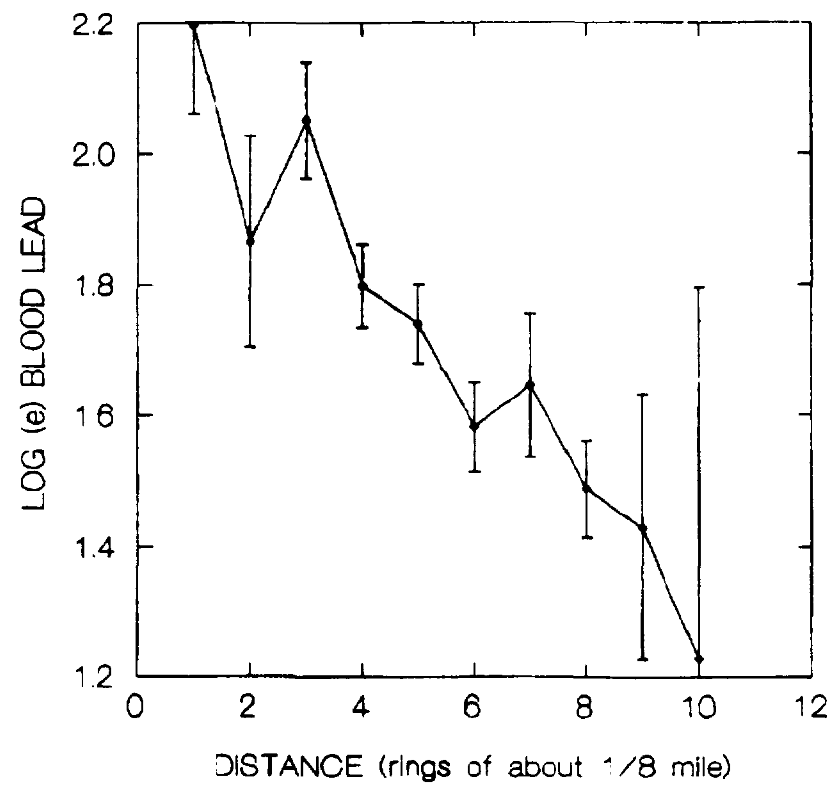

Figure 4a

LOG OF SOIL LEAD CONC. VS. DISTANCE FROM NL SITE

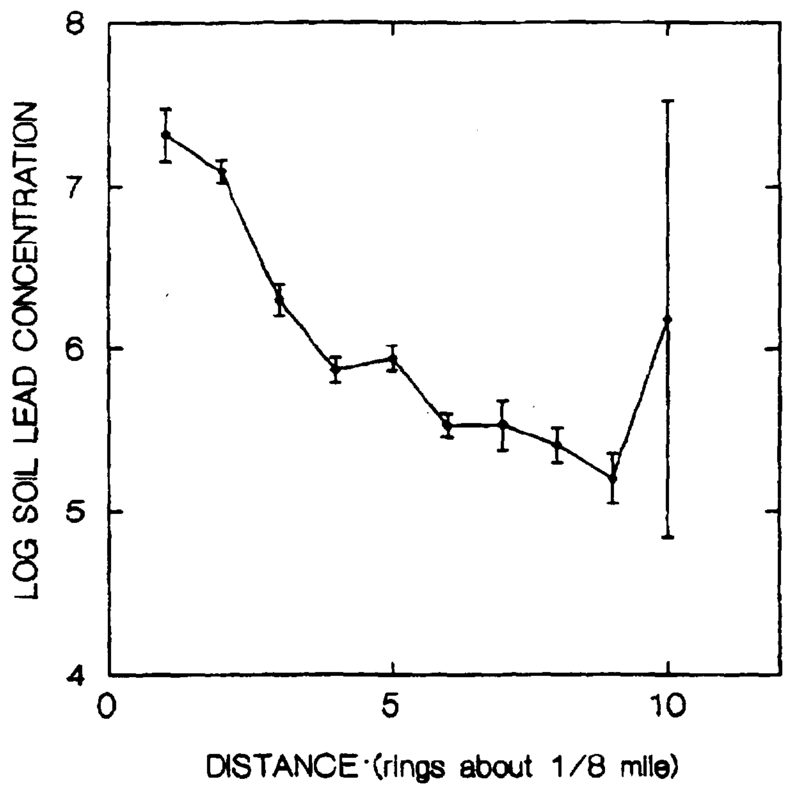

Figure 5

LOG OF DUST LEAD CONC. VS. DISTANCE FROM NL SITE

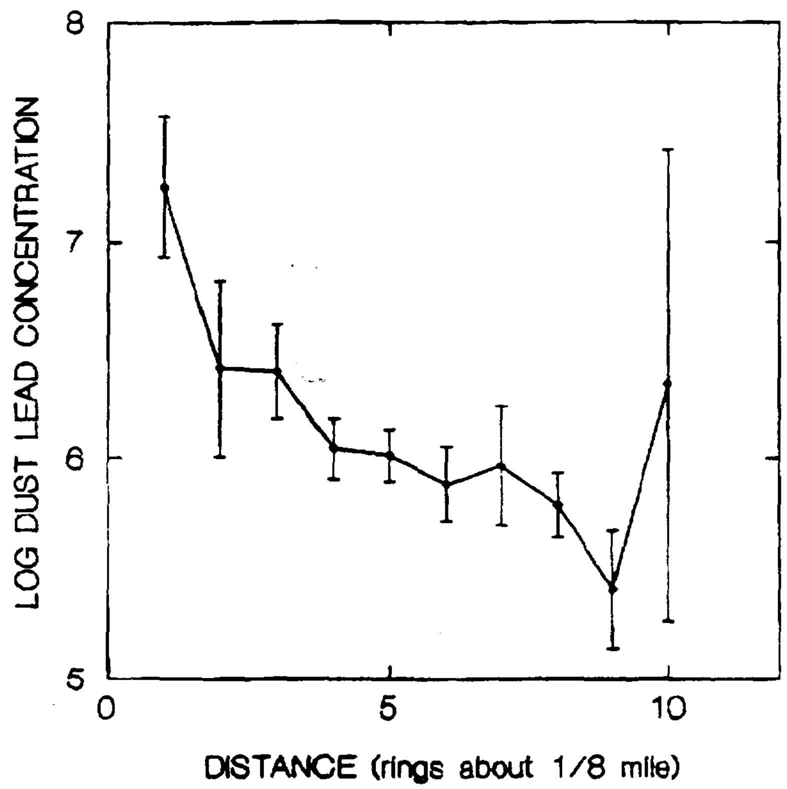

Figure 6

LOG INTERIOR LEAD PAINT VS. DISTANCE FROM NL SITE

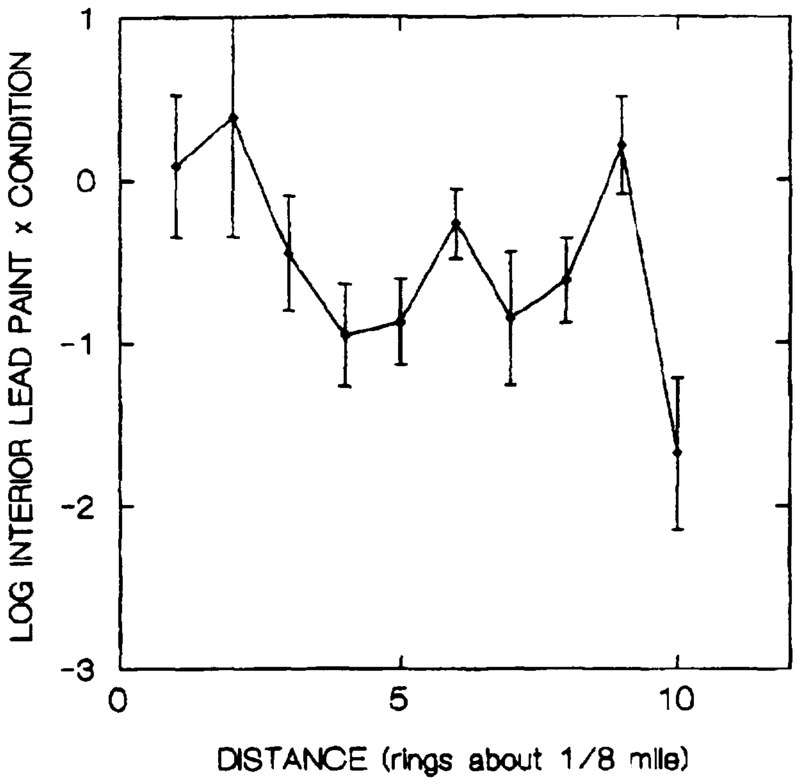

Figure 7

LOG EXTERIOR LEAD PAINT VS. DISTANCE FROM NL SITE

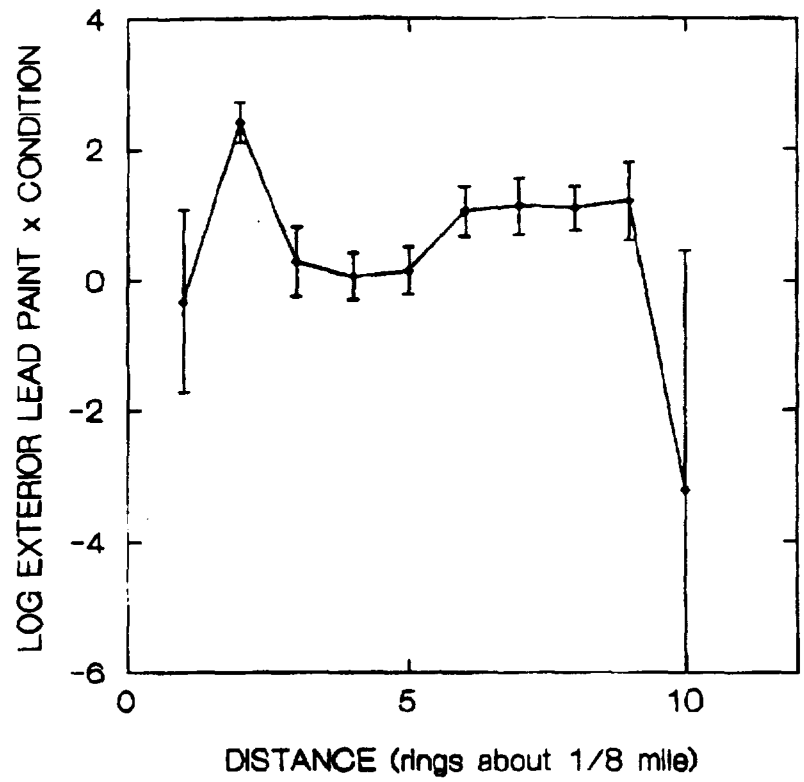

Figure 8

LOG OF WATER LEAD CONC. VS. DISTANCE FROM NL SITE

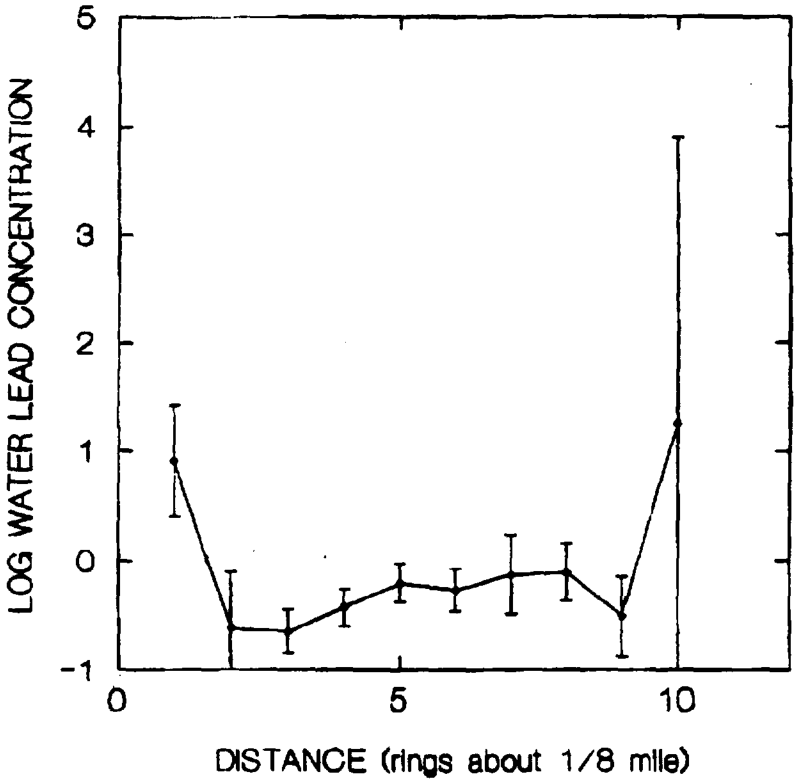

Figure 9

TOTAL DUST LOADING VS. DISTANCE FROM NL SITE

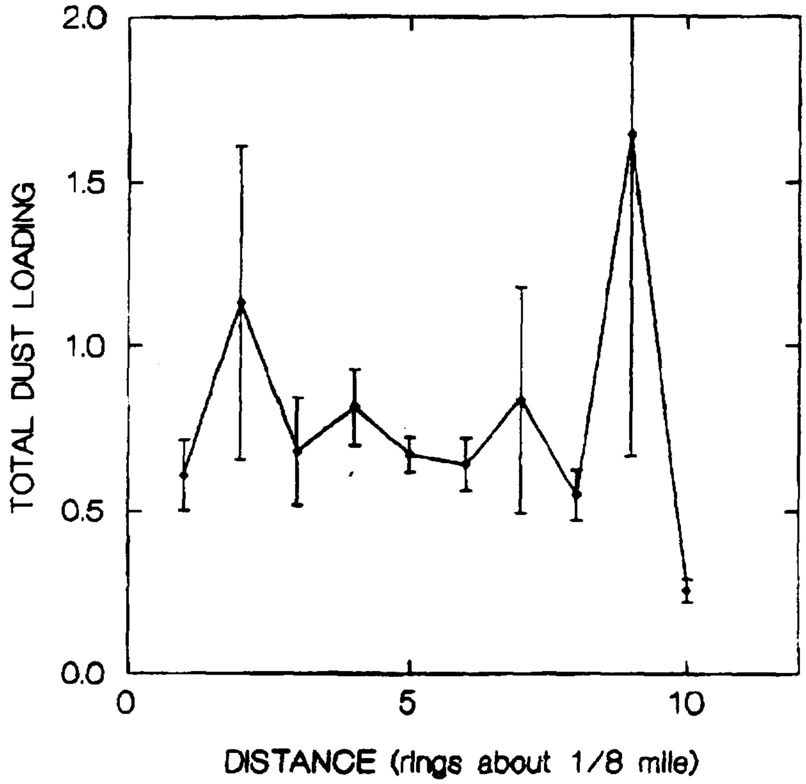

Figure 10

LOG OF DUST LEAD LOADING VS. DISTANCE FROM NL SITE

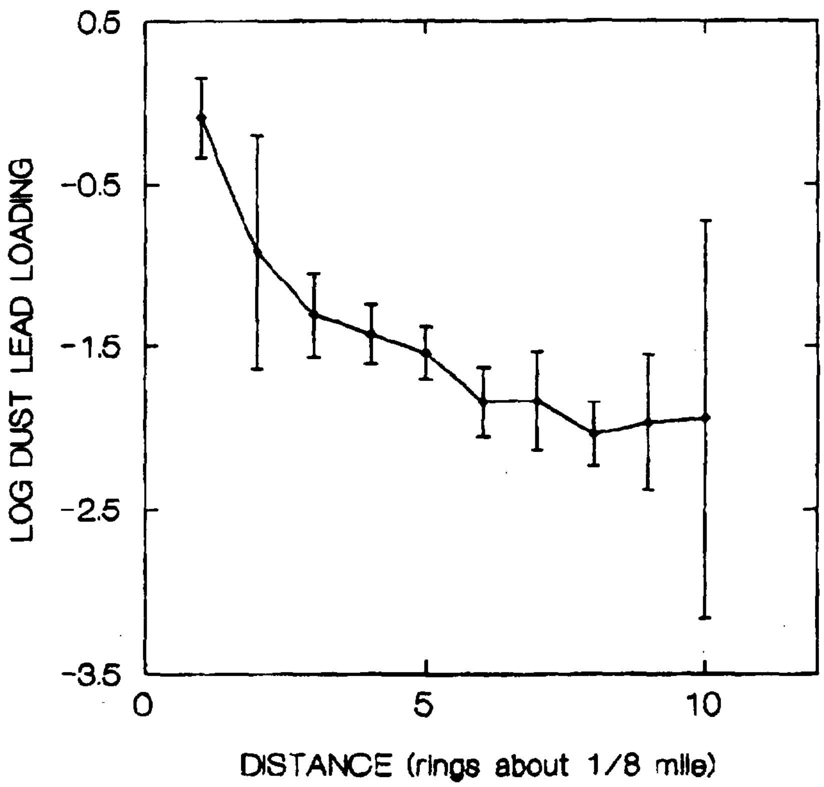

Figure 11

MEAN YEARS OF EDUCATION VS. DISTANCE FROM NL SITE

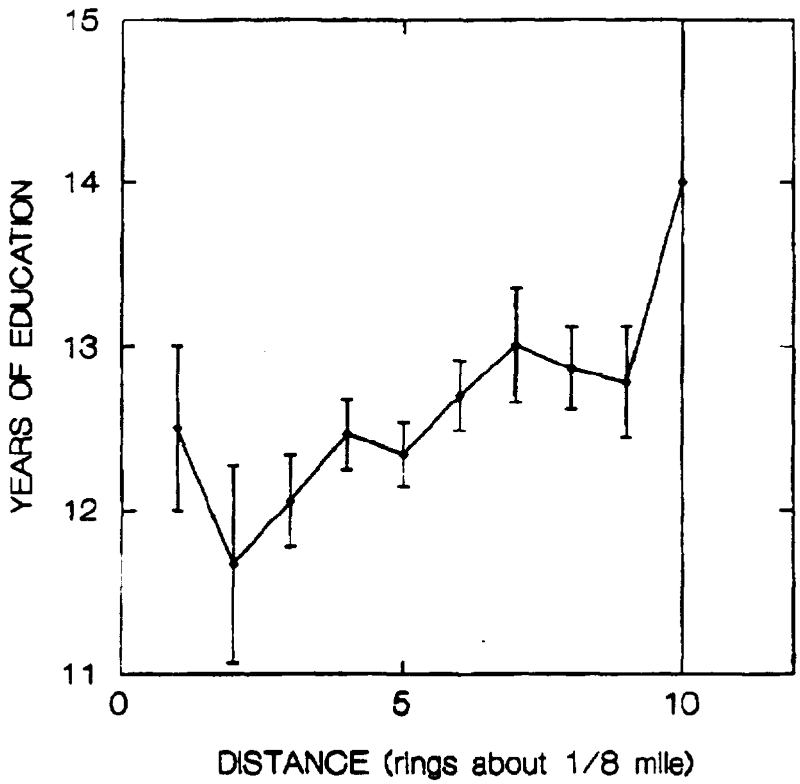

Figure 12

MEAN INCOME VS. DISTANCE FROM NL SITE

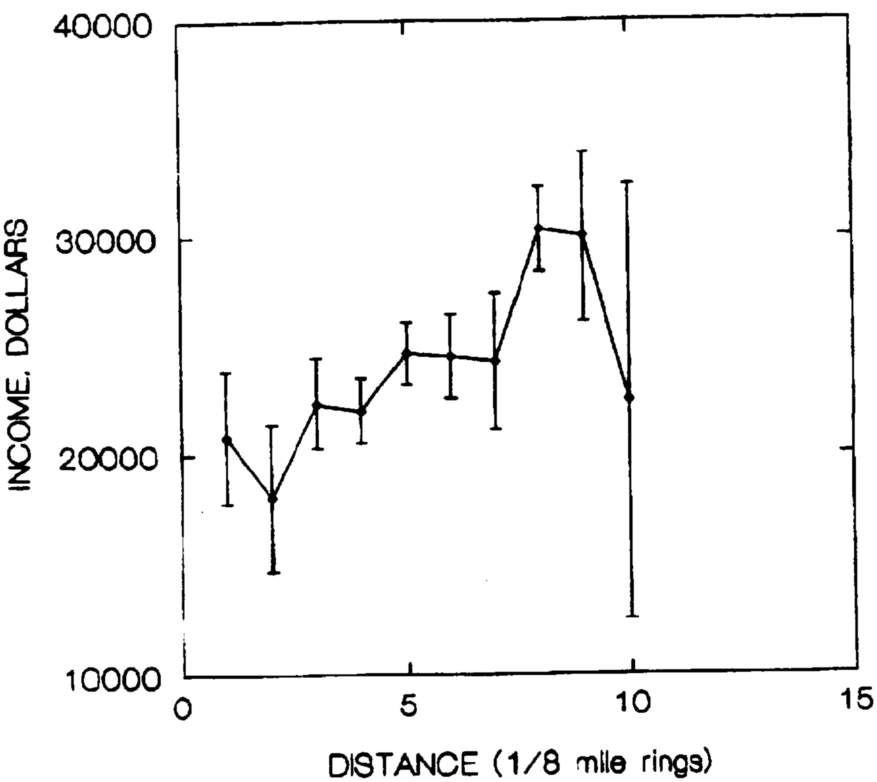

Figure 13

NUMBER OF CHILDREN IN HOUSE VS. DISTANCE FROM NL S

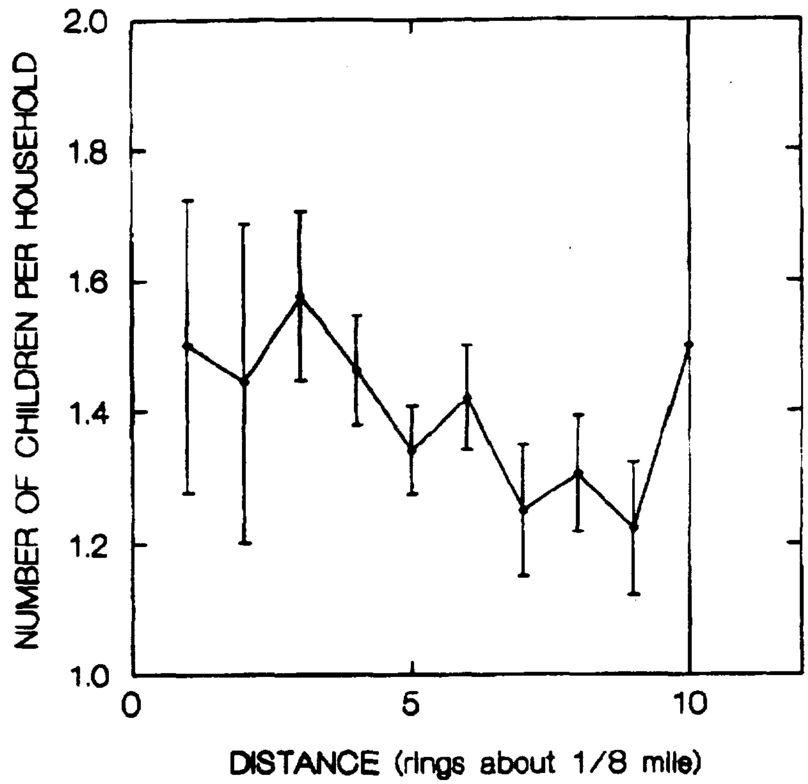

Figure 14

MEAN BUILDING CONDITION VS. DISTANCE FROM NL SITE

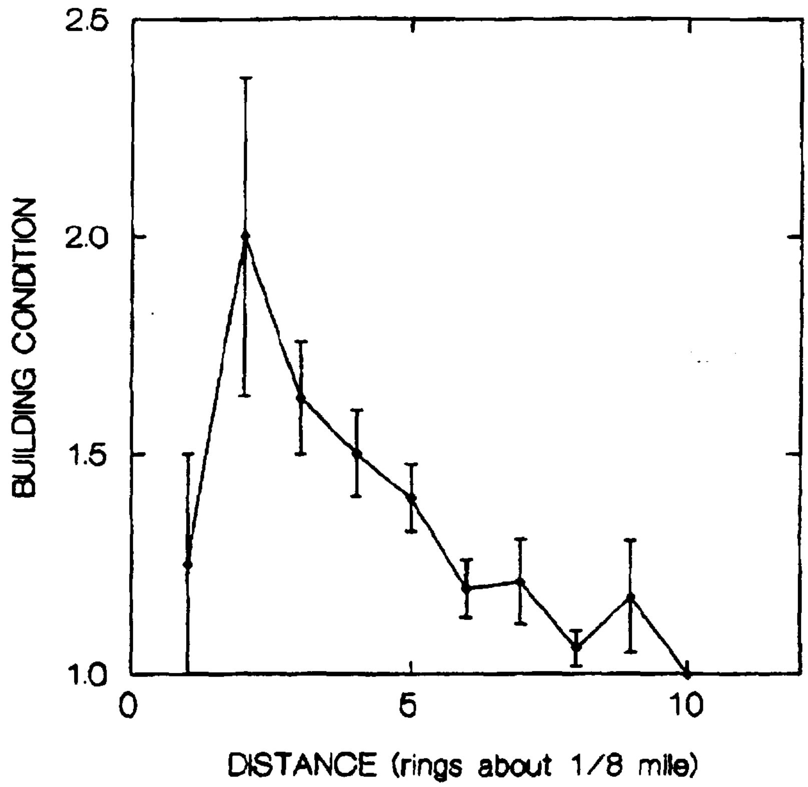

Figure 15

PERCENT WITH AIR CONDITIONING VS. DISTANCE FROM NL S

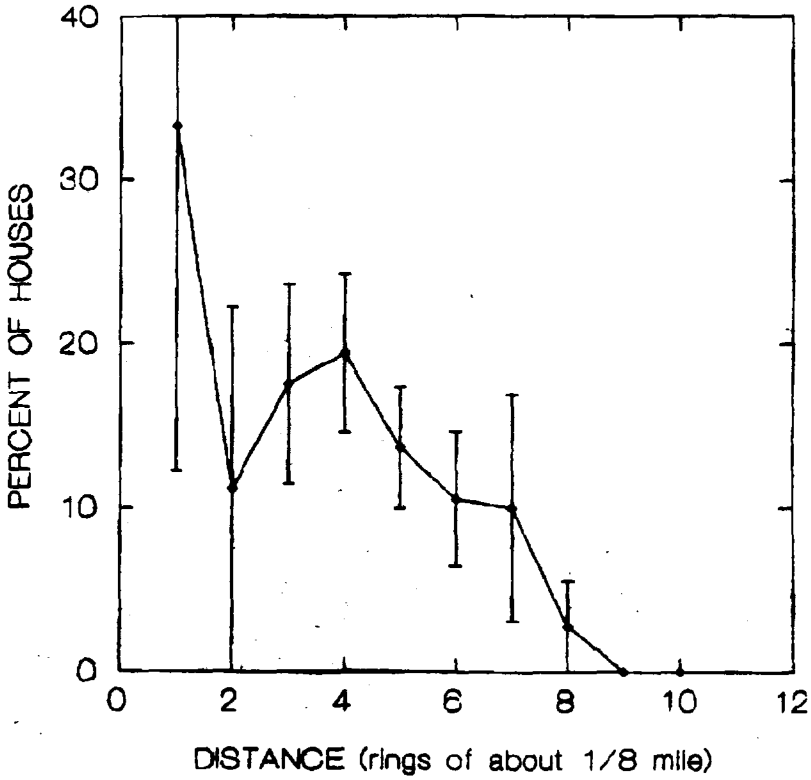

FIGURE 16

HOURS OF OUTDOOR PLAY VS. DISTANCE FROM NL SITE

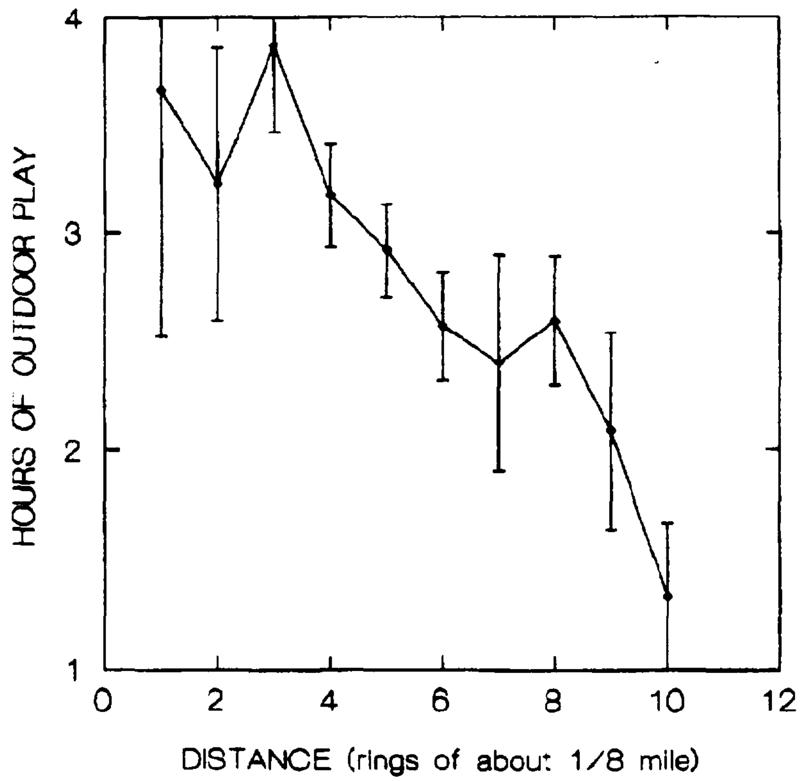

FIGURE 17

HOURS OF PLAY ON FLOOR VS. DISTANCE FROM NL SITE

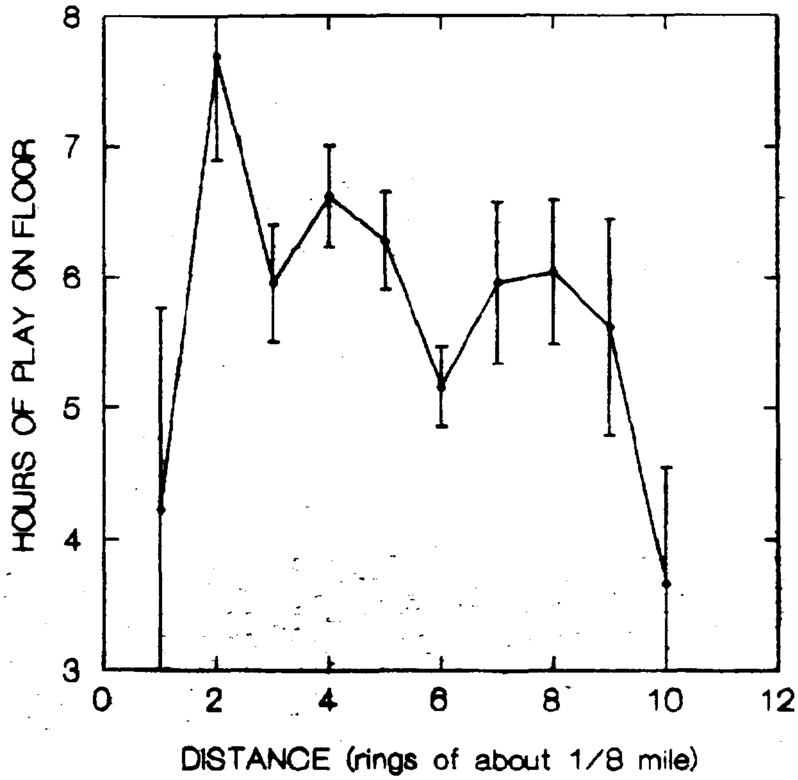

FIGURE 17a

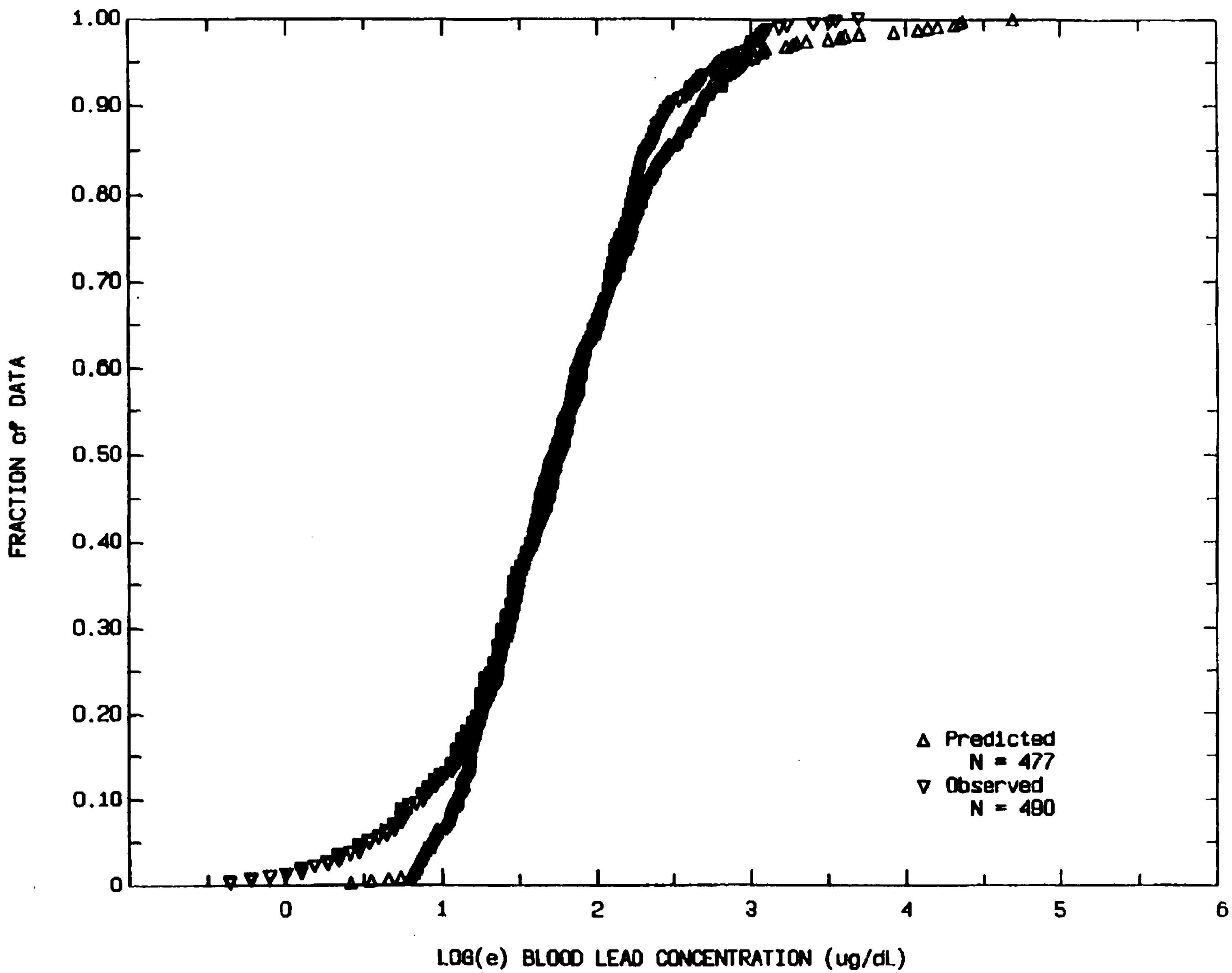

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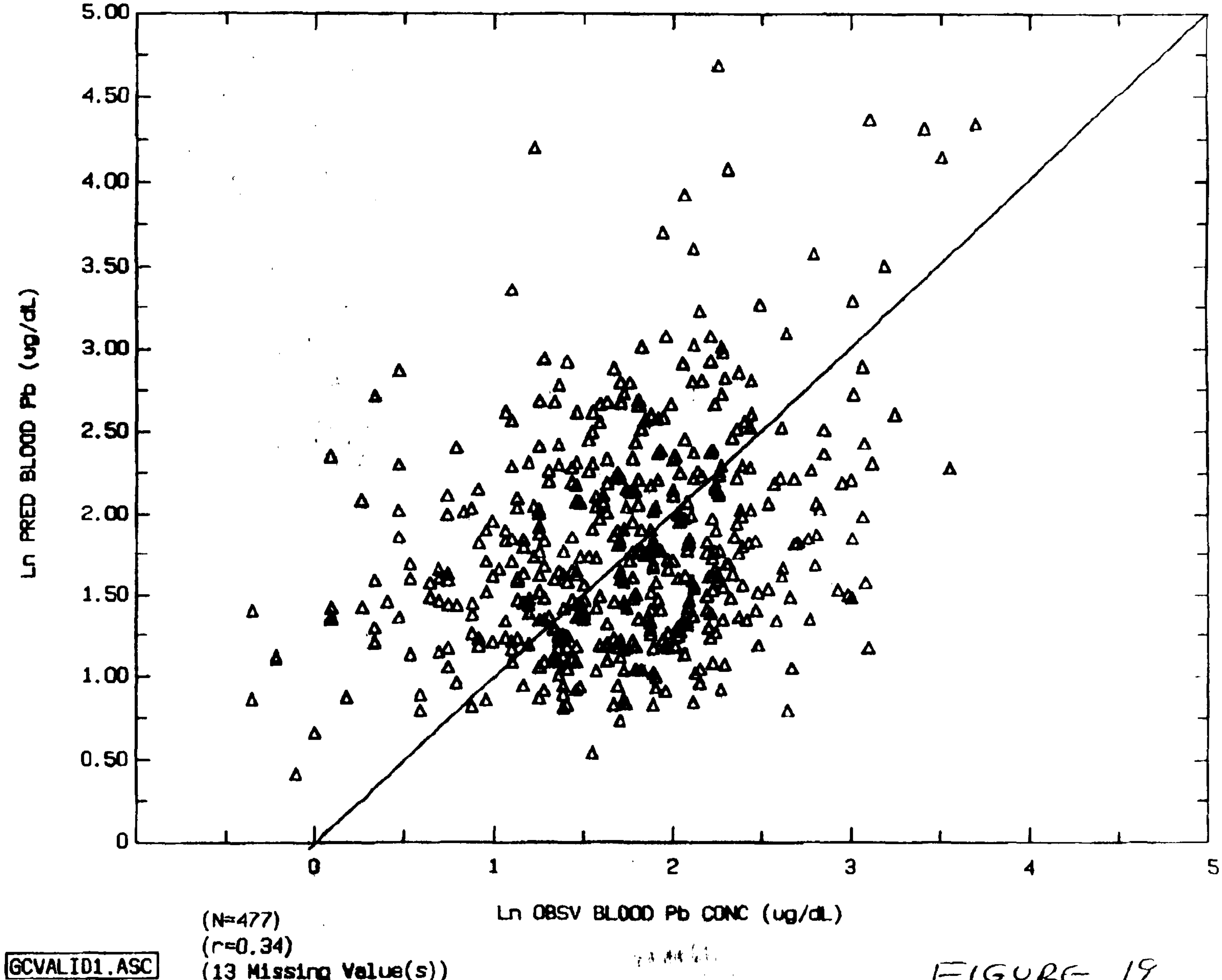
FIGURE 18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4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0
0
1
2
3
4
5
Ln OBSV BLOOD Pb CONC (ug/dL)
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(r=0.34)
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FIGURE 19

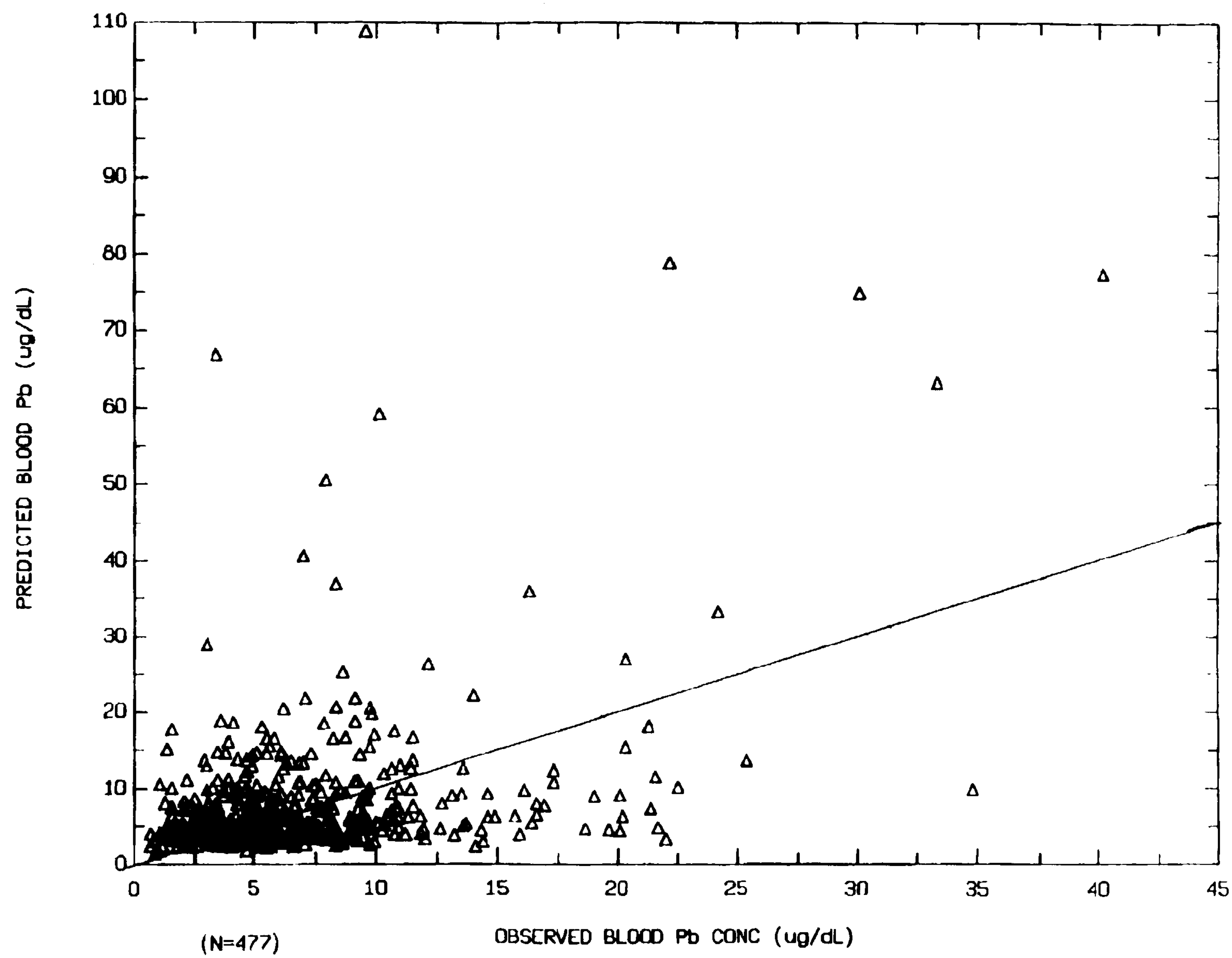

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FIGURE 28